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SOME FACTORS AFFECTING FERTILIZER CONSUMPTION

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Washington D. C.
December 1940

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Farmers in this country have spent around 200 million dollars annually for commercial fertilizer in recent years. This is an average expenditure of about \$30 for each farm in the country. However, the bulk of the fertilizer is consumed in the Atlantic Coast States and here individual farmers sometimes spend as much as \$30 for fertilizer on a single acre of cropland.

The purpose of this report is to show significant trends which have taken place in fertilizer and plant-food consumption, to indicate some of the factors that are responsible for these trends, and to appraise prospects for future fertilizer consumption. Estimates are shown of the proportion of total fertilizer consumption used by specified crops, and the quantity per acre and cost per ton of fertilizer used on leading crops grown on farms of crop correspondents.

The report presents and analyzes some of the considerations in fertilizer use which should be taken into account by farmers. Physical results of an extended experiment of fertilizer use on cotton are subjected to economic analysis to determine the quantity of fertilizer which would have yielded the maximum net return per acre from its use in each of 16 years. Data relative to physical and economic returns from fertilizer used by tobacco farmers in southern Virginia during a period of 17 years are reported and analyzed.

FERTILIZER CONSUMPTION AT HIGH LEVEL

Fertilization of crops had probably been practiced by the Indians in this country for some centuries before its colonization by the White Race. The pilgrims were told by Squanto to place a fish in each hill of corn. Although the fertilizer industry had its beginning around 1824 when the first imports of Peruvian guano took place, the first use of chemical plant food was probably around 1830 when nitrate of soda was imported from Chile.

Domestic production of mixed fertilizers began around 1850 and several years later superphosphate was first manufactured in this country. In 1856 total production of domestic plants was estimated at around 20,000 tons and guano imports at about 60,000 tons. 1/

Following the termination of the Civil War, consumption rose rapidly and was estimated at 1,150,000 tons in 1880 (table 1). From 1880 to 1900 consumption increased more than 90 percent but the most marked increase was from 1900 to 1910. Owing to higher farm incomes, improved fertilizer manufacturing processes, and the continued expansion of the agricultural plant, consumption rose to 5,452,223 tons in 1910 and the increase of 3,252,223 tons was the highest reported for any decade. Consumption continued upward from 1910 until 1914 when it amounted to about 7,100,000 tons.

Use of fertilizers even during the prosperous World War years was less than in 1914. The lower level in these years was due to several reasons. Potash salts from Germany were no longer available, and this, together with shortages and high prices for some other fertilizer materials, tended to check consumption. Also, the ravages of the cotton boll weevil and relatively low cotton prices in the early war years were restricting influences on the use of fertilizer on cotton, the most important outlet.

With the termination of the war and following the high prices realized for the 1919 crops, fertilizer consumption in 1920 slightly exceeded the 1914 figure. A drastic reduction of farm prices began in 1920, and consumption of fertilizer declined in 1921. The 1920 volume was not exceeded until 1925. The trend from 1925 was upward until 1930 when consumption was the largest thus far reported, amounting to about 8,220,000 tons.

From the high level of 1930, consumption declined drastically with the greatly reduced farm incomes of 1930 and 1931 and in 1932 was lower than for any year since 1905. From the low point of 1932, consumption increased each year until 1937 when the tonnage consumed was only slightly below the 1930 peak, but consumption declined in 1938 following the decline of prices of farm crops in 1937.

1/ Willett, Herbert. Fertilizer Consumption in the United States, National Fertilizer Association, 1937. p. 3.

Table 1. - Fertilizer consumption in the United States, 1880-1938 1/

Year	Estimated consumption	Year	Estimated consumption
	Tons		Tons
1880	1,150,000	1918	6,466,186
		1919	6,625,343
1890	1,950,000	1920	7,176,754
		1921	4,862,931
1900	2,200,000	1922	5,669,915
1901	2,500,000	1923	6,442,314
1902	2,770,000	1924	6,824,911
1903	3,075,000	1925	7,333,166
1904	3,360,000	1926	7,323,268
1905	3,850,000	1927	6,843,199
1906	4,450,000	1928	7,985,019
1907	4,452,000	1929	8,010,957
1908	4,525,000	1930	8,220,706
1909	4,912,000	1931	6,353,243
1910	5,452,223	1932	4,384,018
1911	6,023,541	1933	4,907,104
1912	5,766,916	1934	5,582,431
1913	6,336,972	1935	6,273,164
1914	7,099,619	1936	6,900,350
1915	5,323,262	1937	8,194,699
1916	5,124,904	1938	7,504,064
1917	5,925,028		

1/ Data from publications of the National Fertilizer Association.

Willett, Herbert. Fertilizer Consumption in the United States, 1937. p. 9., and the 1939 March-April issue of the Fertilizer Review.

EASTERN STATES HEAVY USERS OF FERTILIZER

Consumption of commercial fertilizers is largely restricted to the States east of the Mississippi and is especially concentrated in the States along the Atlantic Coast. The South Atlantic States alone normally account for more than 50 percent of the total United States consumption. In these States the trend in consumption closely follows the pattern for the United States as a whole (fig. 1). However, consumption in this group of States in recent years has been relatively less than in early years. During 1910-14 these States consumed more than 60 percent of the total fertilizer used in continental United States, and during 1934-38 they consumed slightly more than 51 percent of the total. A relatively high percentage of the crops grown in these States receive applications of commercial fertilizer, and the fertilizer consumed per acre of land for crop use is much higher than for any other group of States (table 2).

FERTILIZER CONSUMPTION BY GEOGRAPHIC AREAS, 1910-38

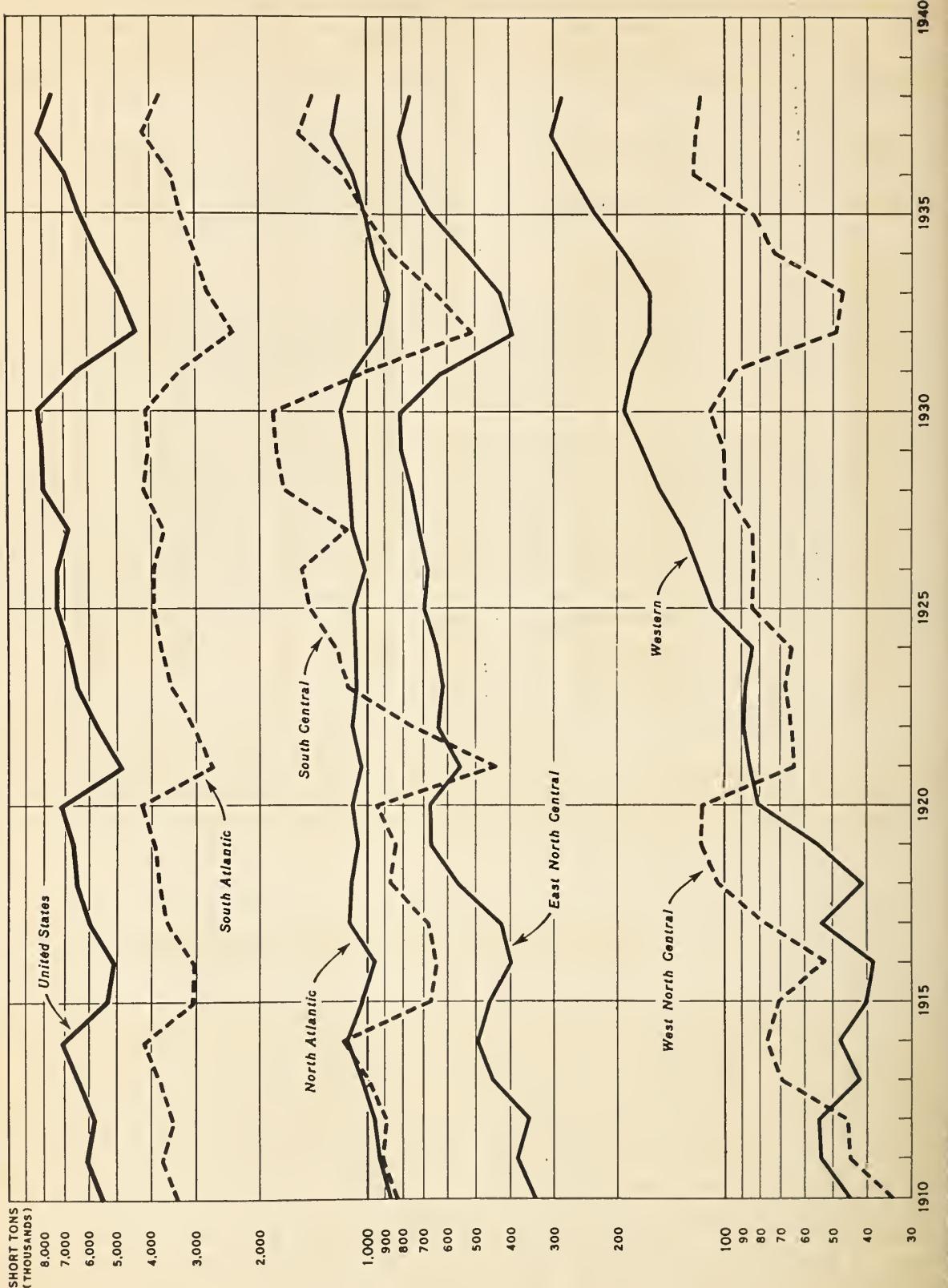


FIGURE 1

Table 2. - Consumption of fertilizer and plant food per acre of land for crop use, 1880-1938 1/

Year	Fertilizer consumption								Plant-food	
	East	West	North	South	Atlantic	Central	United States	United States	United States	2/
1880	-	-	-	-	-	-	-	-	11.4	1.5
1890	-	-	-	-	-	-	-	-	15.4	2.1
1900	-	-	-	-	-	-	-	-	14.4	2.0
1910	74.4	9.9	.6	216.4	22.9	3.7	32.0	4.8		
1911	80.7	11.2	.7	237.1	24.3	4.3	34.9	-		
1912	84.7	10.9	.7	225.9	24.4	4.2	33.7	-		
1913	91.2	13.2	1.1	243.5	20.5	3.2	30.4	-		
1914	100.5	14.7	1.2	271.4	31.0	3.4	40.6	-		
1915	90.0	13.3	1.1	194.5	18.0	2.7	29.8	-		
1916	84.5	11.7	.8	188.3	17.0	2.6	28.8	-		
1917	96.9	12.0	1.2	215.7	17.5	3.5	32.5	-		
1918	95.7	15.3	1.5	220.8	21.8	2.4	34.2	-		
1919	92.6	18.2	1.7	232.3	20.5	3.4	34.9	-		
1920	97.7	18.6	1.7	205.9	23.8	4.5	38.3	5.3		
1921	93.1	15.5	.9	173.3	11.0	4.8	25.9	-		
1922	99.6	19.1	1.0	201.7	19.2	5.0	30.9	-		
1923	98.8	17.8	.9	238.8	23.3	5.0	34.1	-		
1924	101.4	19.0	1.0	260.0	30.1	4.9	37.2	-		
1925	104.6	20.5	1.2	260.7	35.0	6.1	39.4	6.3		
1926	100.1	20.4	1.2	267.5	35.4	6.6	39.5	6.5		
1927	109.9	23.6	1.2	255.4	27.9	7.0	37.4	6.2		
1928	115.9	23.6	1.4	291.6	39.3	7.9	42.6	7.2		
1929	121.3	27.5	1.4	282.1	41.3	8.6	42.8	7.5		
1930	123.0	27.0	1.5	282.2	41.5	9.6	43.3	7.7		
1931	110.1	20.2	1.3	222.4	24.1	9.0	33.1	5.9		
1932	90.7	12.6	.7	155.5	11.4	8.1	22.6	4.1		
1933	86.6	13.7	.7	182.1	14.4	8.1	25.6	4.6		
1934	99.2	17.7	1.1	209.9	20.3	10.2	31.1	5.6		
1935	101.8	21.6	1.2	223.6	23.2	11.9	33.8	6.1		
1936	109.2	25.2	1.8	238.3	20.4	13.8	37.1	6.9		
1937	123.3	26.2	1.7	230.7	34.3	15.7	43.6	8.1		
1938	121.3	25.1	1.7	253.3	32.6	15.0	40.9	7.8		

1/ Fertilizer consumption per acre was obtained by dividing total pounds of fertilizer consumed by the estimated acres of land used for crops. The figures are somewhat high as no adjustment was made for fertilizer used on pastures and for nonagricultural purposes.

2/ Plant food per acre was calculated by multiplying pounds of fertilizer per acre by the plant-food content of complete mixtures, as reported in the National Fertilizer Association's publication, A Survey of Plant Food Consumption in the United States for the Year Ended June 30, 1934, by A. L. Mehring and H. R. Smalley. The assumption that the plant-food content of all fertilizer has changed in about the same proportion as that for complete mixtures seems justifiable for the purpose intended.

The North Atlantic and the South Central States are also important consumers of fertilizer. Each of these groups of States usually consume about one-sixth of the United States total. Consumption in the North Atlantic States has tended slightly upward since 1910. Year to year variations in consumption have been less pronounced than for other groups of States. On the other hand, consumption in the South Central States has varied widely from year to year. The low cotton prices of 1914, 1920, 1926, 1930, and 1931 resulted in sharp declines in fertilizer use in the following years. Consumption of fertilizer per acre of land for crop use is much greater in the North Atlantic than in the South Central States.

Fertilizer consumption in the East North Central States has been increasing and in recent years has approximated 10 percent of the United States total. This figure compares with slightly more than 6 percent in the pre-war period.

Fertilizer consumption in the West North Central and Western States has increased substantially since 1910. During the pre-war years the two groups of States together consumed less than 2 percent of the country's fertilizer and slightly more than 5 percent in the 5 years ending with 1938. Fertilizer consumed per acre of cropland in the West North Central States is much lower than for the Western States or for any other group of States, approximating one pound per acre in most years.

PLANT-FOOD CONTENT OF FERTILIZERS INCREASING

Owing to the marked changes which have taken place in plant-food content of fertilizers, consumption in tons does not reflect fully the changes which have taken place in the use of fertilizers. A ton of fertilizer now contains appreciably more plant food than was the case in earlier years as a result principally of improved manufacturing processes, the increased use of inorganic materials as sources of nitrogen, the increased use of double and triple superphosphates, and the use of higher grade potash salts.

It is estimated that in 1880 when fertilizer consumption per acre of cropland amounted to 11.4 pounds, plant-food consumption amounted to 1.5 pounds (table 2). In 1937, fertilizer consumption averaged 43.6 pounds and plant-food consumption 8.1 pounds per crop acre. The plant-food content of complete fertilizers is believed to be fairly representative of all fertilizers sold for the materials used in complete fertilizers are similar to those sold in other mixtures or as straight goods. The plant-food content of complete fertilizer amounted to 13.4 percent in 1880 and about 19.0 percent in 1938. The plant-food content of fertilizer has increased about 42 percent since 1880.

The plant-food content rose from 13.4 percent in 1880 to 14.9 percent in 1910, and in 1920 declined to 13.9 percent. The low plant-food content of 1920 largely reflected the shortage and high cost of potash. The principal source of potash salts was Germany. Imports from that country ceased during the War period and were at low levels in the years immediately

following the end of the War. Following 1920, the upward trend in the plant-food content of fertilizer was resumed, and in 1925 the plant-food content amounted to 16 percent. The increase from 1925 to 1934 was greater than for any decade thus far reported. During this period the plant-food content increased from 16 percent to 18.1 percent and represented nearly half of the total increase since 1880.

PLANT-FOOD CONTENT VARIES IN DIFFERENT STATES

It has been stated that the consumption of fertilizer in pounds is not a very good indication of fertilizer use in the United States because of differences in the plant-food content of fertilizers at various periods. The same situation applies to States, even when the same period is being considered. The average plant-food content of complete fertilizer mixtures in 1934 was 18.1 percent in the United States, but the range was from a high of around 25 percent for Maine and California to a low of less than 15 percent in the Carolinas and Virginia. 2/

Average plant-food content was highest in the Western and New England States, fairly high in the Midwestern States, about the same as the United States average in the Middle Atlantic States, and below the United States average in the Southern States.

A recent study shows that the plant-food content of fertilizers has changed more since 1880 in some States than in other States. 3/ Relatively small increases in the plant-food content of complete mixtures are indicated for the Southern States, especially North Carolina, South Carolina, Virginia, and Florida. Increases have been most marked in the New England and Western States.

PLANT-FOOD CONSUMPTION HIGH IN ATLANTIC COAST STATES

One of the best indications of the use of commercial fertilizers in different States is the amount of plant food consumed per acre of land for crop use. As has been stated the average plant-food content of fertilizers varies rather widely in different States. For this reason the quantity of fertilizer used per acre of land does not fully reflect plant food consumption. Total fertilizer tonnage figures are also unsatisfactory measures of fertilizer use largely because of the wide differences in acreages of cropland in the different States. According to reports of the Bureau of the Census, land for crop use in 1934 ranged from 31,918,000 acres in Texas to 67,000 acres in Rhode Island.

2/ National Fertilizer Association. A Survey of Plant Food Consumption in the U. S. for the year ended June 30, 1934.

3/ Mehring, A. L., and Peterson, A. J. Changes in Consumption of American Fertilizers, 1880-1932. U. S. Dept. Agr. Cir. 315, 20 pp. 1934.

Table 3 shows the average consumption of plant food per acre of land for crop use in 1934. The figures are somewhat high, since no adjustments for fertilizer used on pastures or for nonagricultural purposes have been made, but the amount used for these purposes in most cases is small, and the data show fairly closely the extent to which fertilizers are used in the different States. Consumption in Florida of about 100 pounds of plant food is the highest for any State. This is obtained from an average application of about 500 pounds of fertilizer containing 20 percent plant food per acre of land for crop use.

The 12 States leading in plant-food consumption per acre of land for crop use are along the Atlantic Coast. In each of these States consumption in 1934 exceeded 20 pounds of plant food per acre. Large acreages of truck crops, fruit, cotton, and tobacco are grown in these States. Then, too, the soils in some sections are naturally of low productivity. Consumption of plant food is relatively high in the States immediately west of the Atlantic Coast States, and relatively low in most States west of the Mississippi River, although California consumes about 8 pounds of plant food from commercial fertilizers per acre of land for crop use.

HIGH-VALUE CROPS HEAVY USERS OF FERTILIZER

Fertilizers are now used to some extent on practically every crop grown in the country but their use is most pronounced on crops that have a high value per acre. Such crops are usually "cash crops," and are relatively concentrated in the heavy fertilizer-using States along the Atlantic Coast.

Several economic and physical considerations account very largely for these developments. Soils along the Atlantic Coast are, in general, inherently less productive than are the soils in many other parts of the country and have been cropped longer. As a result, fertilizer applications bring greater yield responses than in other parts of the country where more fertile soils predominate. Fertilizer-manufacturing plants and fertilizer materials are concentrated largely in close proximity to areas of heavy fertilizer use, and consequently, fertilizer costs to farmers per unit of plant food are relatively low in the heavy-using areas. Then, too, because of nearness to consuming centers, prices received by Eastern farmers for many farm products are substantially higher than the country's average.

The tendency to use more fertilizer on crops of high per-acre value is countrywide and economically sound. The same quantity of fertilizer per acre tends to produce in many areas fairly uniform percentage increases in yield for adapted crops. Thus, with crops of high per-acre value, fertilizer use is more profitable than with crops of low per-acre value, and larger quantities of fertilizer can be used per acre on crops of high values before the point of maximum profit from fertilizer use is reached.

Table 3. - Consumption of plant food from commercial fertilizers, per acre of land for crop use, by States, 1934 1/

State	Plant food:		Plant food:		Plant food:	
	consumed	per acre	consumed	per acre	consumed	per acre
	of land	State	of land	State	of land	State
	for crop		for crop		for crop	
	use		use		use	
	Pounds		Pounds		Pounds	
Florida	99.06	West Virginia	11.00	Texas	0.71	
New Jersey	63.40	Ohio	9.89	Nevada	.64	
Rhode Island	54.81	California	8.60	Idaho	.60	
Maine	51.63	Mississippi	8.21	Illinois	.44	
North Carolina	45.51	Louisiana	7.12	Wyoming	.40	
South Carolina	42.73	Indiana	5.36	Minnesota	.27	
Massachusetts	42.04	Vermont	4.95	New Mexico	.27	
Connecticut	36.74	Tennessee	4.76	Utah	.25	
Maryland	32.43	Kentucky	4.25	Montana	.15	
Delaware	32.07	Michigan	4.09	Oklahoma	.13	
Virginia	27.73	Arkansas	2.35	Iowa	.12	
Georgia	20.40	Washington	2.09	South Dakota	.10	
Alabama	17.71	Oregon	1.85	Kansas	.09	
Pennsylvania	14.61	Missouri	1.57	Colorado	.05	
New York	14.24	Arizona	1.45	North Dakota	.01	
New Hampshire	12.79	Wisconsin	.93	Nebraska	2/	
	:	:	:	:	:	

1/ The amount of plant food was computed for each State from data contained in the National Fertilizer Association's publication, Survey of Plant Food Consumption in the United States for the year ended June 30, 1934. Consumption figures as shown in the report were adjusted in line with the revised estimate of fertilizer consumption as reported in the March-April 1939 issue of the Fertilizer Review. The plant food consumption by States was divided by the number of acres of land for crop use in 1934, as reported by the Bureau of the Census. Land for crop use includes the acreage cropland harvested and crop failure. The figures in the above table are slightly high as no adjustment was made for fertilizer used on pasture and for nonagricultural purposes.

2/ Less than 0.01 pounds.

Table 4 shows the estimated percentage distribution of total fertilizer consumption for selected crops and classes of crops for specified years. Fertilizer consumption in 1924, 1928, and 1930 can be considered as fairly indicative of the usual, but in 1932 consumption was abnormally low, being less than for any year since 1905. The low consumption of 1932 reflected the low farm incomes, and adverse returns from farming in 1931.

Table 5 shows the relationship between acreage and fertilizer used by specified crops and groups of crops and the relative quantity of fertilizer used per acre by different crops.

Table 6 shows the average quantity of fertilizer used per acre for specified crops in 1933. The data were obtained from crop correspondents. (See footnote, table 6.) For cotton, the fertilizer data in table 6 represent acreage usage of all growers in 1933. For the other crops, fertilizer use shown in table 6 is probably somewhat above the average of growers for the country as a whole, but the table does show the relative use and cost per ton of fertilizer for the specified crops, by States, groups of States, and for the United States.

Intertilled field crops account for about 45 percent of the cropland and provide an outlet for about two-thirds of the total fertilizer tonnage used on crops. (See tables 4 and 5.)

In 1924 and in 1928, approximately 30 percent of the total fertilizer tonnage was used on cotton. In 1932 and in 1933, cotton acreages were relatively small, and in each year fertilizer used on cotton amounted to only about 20 percent of the total United States consumption. In 1924 and in 1928, cotton used more fertilizer than any other single crop, but in 1932 and in 1933 fertilizer used on cotton was slightly less than the quantity used on corn.

Fertilizer used per acre of cotton is, however, in excess of the quantity used on any other crop that is grown on as extensive an acreage as cotton; it is about 2.5 times the average quantity used per acre on all crops. Thus, with about 10 percent of the total cropland, cotton utilizes about 25 percent of the fertilizer tonnage. (See table 5.)

Fertilizer use on cotton is most pronounced in the South Atlantic States, but important quantities are also used in the East South Central States. In the West South Central States only small quantities are used on cotton and these are confined largely to Louisiana, Arkansas, and eastern Texas. In Oklahoma, central and western Texas, and in the irrigated areas practically no fertilizer is used on cotton.

In the more Eastern Cotton areas complete fertilizers are commonly used, whereas, in the more Western areas, nitrogen fertilizers are sometimes used exclusively. The relatively high price per ton of fertilizer in the West South Central States reflects this usage.

Table 4. - Estimated percentage of total United States consumption of fertilizer used by indicated crops in indicated years 1/

Crop	1924	1928	1932	1936
	Percent	Percent	Percent	Percent
Intertilled field crops:				
Cotton	28.64	29.67	19.55	19.96
Corn	21.28	20.10	20.18	22.56
White potatoes	8.32	8.14	10.41	7.36
Tobacco	6.69	7.81	5.76	6.19
Sweet potatoes	1.30	1.37	1.89	1.66
Peanuts	1.10	1.10	1.33	1.04
Sugar beets	.24	.21	.34	.37
Sugarcane	.41	.40	.50	.46
Dry beans	.24	.16	.28	.22
Soybeans	.17	.21	.20	.36
Other intertilled crops 2/	1.86	1.77	1.70	2.12
Total	70.25	70.94	62.14	62.30
Small grains:				
Wheat	7.94	6.34	7.48	10.09
Oats	4.29	4.24	4.99	3.57
Barley	.20	.47	.55	.40
Rice	.17	.17	.05	.19
Other small grains 3/	.73	.58	.75	.51
Total	13.33	11.80	13.82	14.76
Tame and wild hays	3.65	3.30	4.08	4.35
Fruits and tree nuts:				
Citrus	3.47	4.10	6.48	6.25
Apples	1.25	1.14	1.47	1.07
Peaches	.63	.57	.57	.47
Other tree fruits	.49	.68	1.00	.82
Grapes	.14	.16	.25	.20
Small fruits	.90	1.01	1.42	1.01
Tree nuts	.12	.15	.15	.16
Total	7.00	7.81	11.34	9.98
Vegetable crops:				
Tomatoes	1.33	1.13	1.51	1.60
Cabbage	.52	.56	.78	.82
Sweet corn	.54	.55	.69	.71
Watermelons	.52	.57	.62	.58
Snap beans	.36	.47	.65	.70
Celery	.25	.33	.56	.45
Cucumbers	.35	.35	.38	.39
Asparagus	.21	.32	.54	.44
Lettuce	.18	.25	.55	.52
Onions	.27	.29	.41	.35
Green peas	.22	.23	.31	.36
Peppers and pimentos	.14	.16	.27	.21
Cantaloupes	.12	.11	.18	.16
Spinach	.11	.14	.15	.13
Lima beans	.07	.07	.12	.14
Cauliflower	.04	.05	.11	.08
Other vegetables 4/	.54	.57	.79	.97
Total	5.77	6.15	8.62	8.61
Total all crops	100.00	100.00	100.00	100.00

1/ In compiling the above data, fertilizer consumption of each State as reported by the National Fertilizer Association was distributed to the various crops according to the relative use of fertilizer on each crop as indicated by various farm-practice studies, cost of production studies, and fertilizer-utilization studies. Some of the fertilizer consumed is used on pastures and for nonagricultural purposes, but this quantity is small and was not deducted from the total in making the above percentage estimates.

2/ Includes cowpeas for grain, grain sorghums, sorghums for sirup, sorghums for silage, sorghums for forage and hay, mint, hops, Canadian peas, broomcorn, pop corn, chicory, hemp, farm gardens, and miscellaneous field crops.

3/ Includes buckwheat, rye, flax, emmer and speltz.

4/ Includes carrots, beets, eggplant, kale, turnips, squash, rhubarb, okra and other vegetables.

Table 5. - Estimated distribution of cropland and the total United States consumption of fertilizer by crops, average of selected years 1/

Crop	Percentage of cropland in indicated crop 2/	Percentage of fertilizer used on indicated crop	Index of fertilizer used per acre 3/ (Average quantity per acre all crops = 100)
	Percent	Percent	:
Intertilled field crops:			
Cotton	10.04	25.17	251
Corn	27.85	21.07	76
White potatoes	.86	8.37	976
Tobacco	.44	6.75	1,548
Sweet potatoes	.20	1.52	755
Peanuts	.54	1.12	208
Dry beans	.42	.22	52
Soybeans	.28	.23	85
Sugar beets	.21	.28	131
Sugarcane	.09	.43	465
Other intertilled crops	3.61	1.87	52
Total	44.54	67.03	150
Small grains:			
Wheat	17.09	7.93	46
Oats	10.90	4.20	39
Barley	3.07	.40	13
Rice	.25	.16	63
Other small grains	2.16	.63	29
Total	33.47	13.32	40
Tame and wild hays			
	19.27	3.80	20
Fruits and tree nuts:			
Citrus	.22	4.89	2,244
Apples	.72	1.21	167
Peaches	.21	.56	273
Other tree fruits	.29	.72	246
Grapes	.19	.18	94
Small fruits	.10	1.05	1,063
Tree nuts	.16	.14	88
Total	1.89	8.75	462
Vegetable crops:			
Tomatoes	.14	1.37	957
Cabbage	.05	.66	1,367
Sweet corn	.12	.61	526
Watermelons	.07	.57	760
Snap beans	.06	.53	911
Celery	.01	.38	4,244
Cucumbers	.03	.37	1,307
Asparagus	.02	.36	1,444
Lettuce	.03	.35	1,032
Onions	.03	.32	1,235
Green peas	.08	.27	321
Peppers and pimentos	.01	.19	2,350
Cantaloupes	.04	.14	386
Spinach	.02	.13	838
Lima beans	.01	.10	1,238
Cauliflower	.01	.06	1,033
Other vegetables	.10	.69	700
Total	.83	7.10	863
Total all crops	100.00	100.00	100

1/ Average of 1924, 1928, 1932 and 1936.

2/ Cropland includes the acreage of crops harvested, the nonbearing acreage of fruits and tree nuts and the estimated acreage of land abandoned because of crop failure.

3/ Average fertilizer consumption per acre of cropland was about 35 pounds.

Corn provided the largest single outlet for commercial fertilizer in 1932 and 1936 and was second in importance in 1924 and 1928. However, corn uses fertilizer to a lesser extent than it utilizes cropland, and, as a result, average fertilizer use per acre of corn is about 75 percent of the average amount used per acre for all cropland (table 5). Fertilizer use per acre of corn is highest in the Northeastern States, and in the States along the Atlantic Coast north of Georgia. Little fertilizer is used on corn in the West North Central States, the Mountain States, and the Pacific Coast States. The average cost to farmers for a ton of fertilizer in the Mountain and Pacific Coast States is considerably above the country's average.

White potatoes are grown on less than one percent of the country's cropland but use more than 8 percent of the total fertilizer. Applications of fertilizers are especially heavy in the commercial potato areas along the Atlantic Coast extending from Maine to Florida. In New England, especially, fertilizers of high analyses are commonly reported. The high per-ton cost of potato fertilizer in New England reflects more plant food per ton of fertilizer than is the case in most other Eastern potato States (tables 5 and 6).

Tobacco is also a heavy user of fertilizer in relation to the acreage grown. Less than one-half of 1 percent of the cropland is used for tobacco but the crop utilizes about 7 percent of the country's fertilizer.

Of the States included in the 1936 study, fertilizer use per acre of tobacco was heaviest in the South Atlantic States where flue-cured is the principal tobacco grown. Burley, fire-cured and dark air-cured tobaccos are grown in the East South Central States, and here fertilizer use per acre is about one-third of the average used in the South Atlantic States.

Sweetpotatoes, sugarcane, and peanuts use relative large amounts of fertilizer per acre but are grown only on a small proportion of the cropland and thus account for only a small percentage of the total fertilizer used.

Small grains and hay crops utilize small quantities of fertilizer in relation to the acreages on which they are grown but they are grown on an extensive scale. Wheat, the most important small grain in both fertilizer consumption and acreage, utilizes only about 8 percent of the total fertilizer consumed on about 17 percent of the total crop acreage.

Fertilizer use per acre for tame and wild hays is much less than for other groups of crops but, owing to the large acreages involved, hay crops use about 4 percent of the total tonnage of fertilizer.

Fruits are large users of fertilizer in relation to land utilized for their production. Fruits and tree nuts occupy less than 2 percent of the cropland but they utilize about 9 percent of the total tonnage of fertilizer consumed. Citrus fruits are the most important fertilizer users in this group, but apples, small fruits, and peaches are also fairly important.

Table 6. - Fertiliser applied per acre, and the price paid per ton for fertiliser by farmers for specified crops harvested in 1938 1/

State and division	Corn		Wheat		Potatoes	
	Fertiliser		Fertiliser		Fertiliser	
	Quantity per acre	Price per ton	Quantity per acre	Price per ton	Quantity per acre	Price per ton
New England	Pounds	Dollars	Pounds	Dollars	Pounds	Dollars
	227	34.70	-	-	1,665	35.60
Middle Atlantic						
New York	142	25.60	245	25.50	445	25.60
New Jersey	255	25.60	230	26.50	1,930	25.00
Pennsylvania	141	25.60	225	25.20	662	25.20
Total	151	26.20	230	25.40	706	25.20
East North Central						
Ohio	52	25.20	176	25.60	451	31.30
Indiana	57	25.90	121	25.70	223	31.30
Illinois	7	30.60	22	27.40	31	31.80
Michigan	36	25.70	120	25.40	152	33.70
Wisconsin	38	32.60	5	32.60	55	37.90
Total	57	30.10	106	28.70	183	33.10
West North Central						
Minnesota	4	40.70	1	50.30	54	43.60
Iowa	6	31.20	7	42.00	23	36.50
Missouri	5	25.60	53	27.70	95	30.40
North Dakota	2/	-	2/	56.50	8	35.70
South Dakota	2/	-	2/	49.00	28	40.50
Nebraska	2/	-	2/	-	5	25.00
Kansas	7	25.20	7	40.30	2	30.80
Total	3	32.30	5	32.30	34	39.10
South Atlantic						
Delaware	139	25.80	304	25.00	781	29.20
Maryland	135	25.00	308	24.20	745	27.50
Virginia	136	22.60	278	22.20	1,349	27.40
West Virginia	120	25.90	194	25.00	605	29.80
North Carolina	206	28.60	204	24.40	1,091	27.00
South Carolina	188	24.00	206	23.00	1,364	23.90
Georgia	84	24.80	161	25.90	385	25.40
Florida	87	24.60	3/	3/	1,787	26.30
Total	134	24.40	271	24.20	1,132	27.20
East South Central						
Kentucky	51	25.60	112	24.90	366	28.60
Tennessee	40	22.40	112	22.40	422	27.70
Alabama	68	25.60	135	24.30	540	26.80
Mississippi	36	29.00	3/	3/	346	27.30
Total	50	26.70	112	25.50	516	27.50
West South Central						
Arkansas	13	30.80	28	30.50	291	30.90
Louisiana	58	31.60	3/	3/	404	32.00
Oklahoma	2	27.20	2/	25.40	171	33.40
Texas	9	31.10	2/	-	127	32.10
Total	16	31.20	1	27.70	247	31.90
Mountain						
Montana	2	35.30	2/	52.50	132	50.20
Idaho	1	52.00	1	53.00	18	51.20
Wyoming	2/	49.50	2/	-	2/	-
Colorado	2/	53.30	2/	50.00	1	42.50
New Mexico	2/	-	2/	-	1	46.00
Arizona	2/	-	4/	47.00	215	30.00
Utah	2/	-	2/	-	97	45.00
Nevada	2/	-	2/	-	2/	-
Total	2/	45.50	2/	51.90	2/	47.60
Pacific						
Washington	22	35.80	2/	36.50	185	36.70
Oregon	1/	40.80	1/	46.00	110	46.50
California	1/	4/	1/	4/	248	36.90
Total	12	37.50	2/	44.80	194	38.30
United States	39	26.80	27	27.00	437	32.50

Table 6. - Fertiliser applied per acre, and the price paid per ton for fertiliser by farmers for specified crops harvested in 1938 1/ - Continued

State and division	Oats		State and division	Oats		
	Fertiliser			Fertiliser		
	Quantity per acre	Price per ton		Quantity per acre	Price per ton	
New England	Pounds	Dollars	South Atlantic	Pounds	Dollars	
	66	30.00	Delaware	211	24.20	
Middle Atlantic			Maryland	253	23.60	
New York	198	22.80	Virginia	204	21.50	
New Jersey	172	22.70	West Virginia	181	23.50	
Pennsylvania	177	23.00				
Total	186	22.90		189	22.70	
East North Central						
Ohio	64	27.10	Mountain			
Indiana	11	27.60	Montana	2/	-	
Illinois	4	19.40	Idaho	2/	-	
Michigan	47	25.50	Wyoming	2/	-	
Wisconsin	10	31.90	Colorado	2/	-	
Total	19	27.70	New Mexico	2/	-	
West North Central			Arizona	2/	-	
Minnesota	3	37.00	Utah	2/	51.00	
Iowa	1	36.70	Nevada	2/	-	
Missouri	12	26.80	Total	1	53.00	
North Dakota	2/	-	Pacific			
South Dakota	2/	-	Washington	3	26.60	
Nebraska	2/	-	Oregon	4	38.00	
Kansas	2	36.80	Total	4	34.50	
Total	3	32.10				
	Cotton			Cotton		
South Atlantic			Mountain			
Virginia	390	24.00	New Mexico	-	-	
North Carolina	426	24.00	Arizona	-	-	
South Carolina	365	25.00				
Georgia	294	24.00	Pacific			
Florida	244	24.50	California	-	-	
Total	348	23.70				
East South Central			Missouri	16	31.00	
Tennessee	106	27.50	Other	24	31.00	
Alabama	294	25.00	United States	117	25.70	
Mississippi	151	29.00				
Total	201	26.70				
West South Central						
Arkansas	58	31.00				
Louisiana	96	33.00				
Oklahoma	1	28.00				
Texas	9	30.50				
Total	22	31.50				
	Tobacco			Tobacco		
South Atlantic			East South Central			
Virginia	804	25.80	Kentucky	250	29.80	
North Carolina	968	25.80	Tennessee	311	27.10	
South Carolina	818	25.10				
Georgia	1,013	29.70	Total	265	29.00	
Florida	861	30.90				
Total	931	26.50				
	Sugar beets			Sugar beets		
East North Central			Mountain			
Ohio	212	30.30	Montana	93	51.60	
Indiana	242	27.00	Idaho	65	48.40	
Illinois	124	39.20	Wyoming	75	50.10	
Michigan	207	32.50	Colorado	22	50.10	
Wisconsin	162	37.50	Utah	69	50.60	
Total	205	32.00	Total	61	50.20	
West North Central						
Minnesota	73	32.60	Pacific			
Iowa	156	30.00	Washington	198	39.10	
North Dakota	51	57.20	Oregon	115	39.60	
South Dakota	66	43.60	California	16	34.80	
Nebraska	50	50.00				
Kansas	34	50.00	Total	35	37.50	
Total	50	41.60	United States	85	38.80	

1/ The indicated application of fertiliser is the total application of the reporting farms divided by the total acreage of the crop grown. In addition to the data in the above table, information was obtained for the following crops: Citrus fruits, in Florida, an average of 19 lbs. of fertiliser @ \$35.20 per ton was applied per tree, California, 5 lbs. of fertiliser @ \$36.30 per ton was applied per tree. Hay crops, New England, 3/4 lbs. of fertiliser @ \$34.00 per ton was applied per acre, Pasture, New England, 13 lbs. of fertiliser @ \$33.40 per ton was applied per acre.

2/ Less than 0.5 lb.

3/ Crop not reported in these States.

4/ No information available.

5/ Averages for States reporting weighted by 1938 acreages.

Bureau of Agricultural Economics and Agricultural Marketing Service. Compiled from information obtained from crop reporters. The data, except for fertiliser used on cotton, have their application to farms operated by crop reporters. In the case of fertiliser used on cotton, crop reporters supplied information relative to the average usage in their locality.

Consumption of fertilizer by vegetable crops is also large in relation to acreage grown. For all vegetable crops the index of fertilizer use per acre is about 900. Tomatoes, cabbage, sweet corn, watermelons, and snap beans are the vegetables which provide the largest outlet for commercial fertilizer. Per-acre use of fertilizer on celery, peppers, and asparagus, however, is larger than for other vegetables and greatly exceeds the quantity used for most other crops.

FERTILIZER EXPENDITURES RELATED TO AGRICULTURAL INCOME

Farmers try to use their resources in ways that will return them the greatest incomes. Money spent for commercial fertilizers merely represents a transaction in which a cash resource is exchanged for an element of production with the hope that in the end the exchange will increase the cash income from the farming operations. Two factors are evident in any such consideration. These are increase in physical product as a result of additional application of fertilizer, and value of the additional product in relation to cost incident to the use of the fertilizer.

Experience has led individuals to follow certain general practices with respect to the use of fertilizers under conditions prevailing at a given time. These practices vary widely because of numerous conditions, like soil and climate, knowledge of the returns to be expected from the use of various kinds and quantities of fertilizers, and relationships between the cost of fertilizer and the prices of farm products.

In periods of low prices for agricultural products the general tendency is for farmers to reduce operating costs, and in periods of high prices this tendency is reversed. As commercial fertilizer is an item of cash expense, the general tendency is to curtail expenditures for fertilizer in periods of low income and to increase expenditures for fertilizer in periods of high income.

This tendency is illustrated by data contained in figure 2. 4/ These data, for the United States, show a close relationship between gross income from agricultural production and the amount spent in the following year for commercial fertilizers. This relationship is much closer than the relationship between gross income and the tonnage of fertilizer and of plant food consumed, especially during the World War period, and during the subsequent period of prosperity. Since 1929 fertilizer prices have been reduced substantially, and consumption has declined relatively less than has income from farm production.

4/ The indexes of fertilizer consumption and plant-food consumption for the United States are based on data of the National Fertilizer Association, with 1910-14 equal to 100 percent. The index of fertilizer purchases is based on data of the Bureau of Agricultural Economics with 1910-14 equal to 100 percent, and the index of gross income from farm production is based on data of the Bureau of Agricultural Economics, with 1909-13 equal to 100 percent.

The fertilizer data are charted for the year to which the data apply and the income data are charted for the previous year. Thus, fertilizer data shown for 1910 represent fertilizer purchases and consumption in 1910, and the income data charted for 1910 actually represent the income in the previous year, or 1909, and so on. Data on plant-food consumption were estimated as indicated in the footnote to table 2 for 1910-14, and for each year since 1924. A satisfactory basis of similar estimates for intervening years was not available.

CONSUMPTION OF FERTILIZER AND FERTILIZER PLANT FOOD, FERTILIZER PURCHASES, AND GROSS
INCOME FROM FARM PRODUCTION IN THE PRECEDING YEAR, U. S., 1910-38

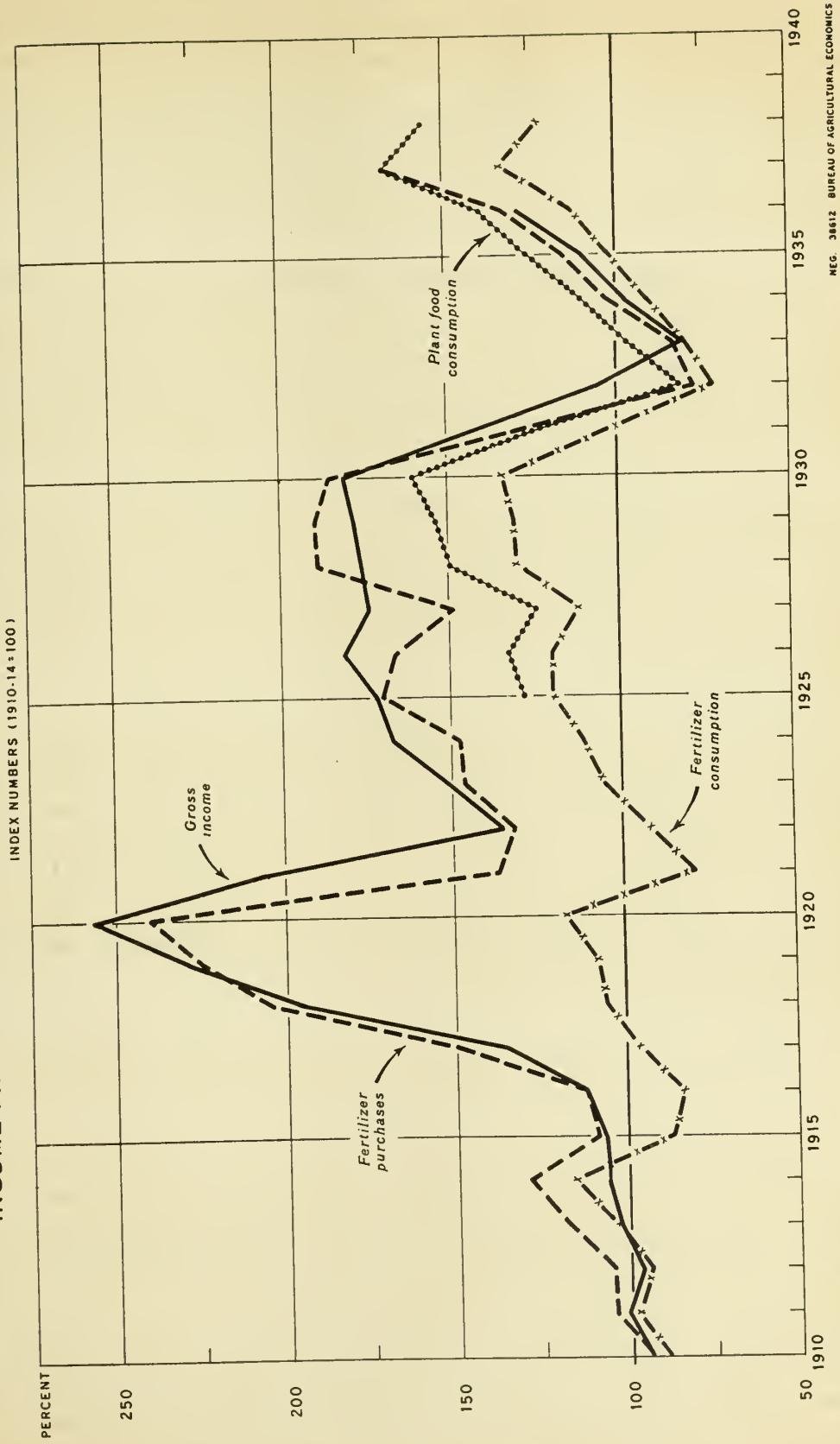


FIGURE 2

The relationships shown indicate that farmers as a whole spend for commercial fertilizers a rather uniform proportion of the previous year's gross income from farm production. The tonnage consumed over a period of years, therefore, will depend largely upon the price relationship of fertilizers and farm products, and prices of farm products will depend to a large extent upon supply of the products. Thus, adjustments in production automatically cause adjustments in the quantity of fertilizer used in agriculture. This may be explained more fully, as follows:

Prices substantially in excess of fertilizer and other costs provide a profit incentive for increasing production through the use of more fertilizer in order to increase yields on land in cultivation and to increase production by bringing additional land into cultivation. When the resulting increase in volume of production becomes so large in relation to consumers' needs that prices are reduced below production costs, expenditures for fertilizer and other cost goods are curtailed and production is adjusted downward.

This balancing process applies to periods of time and not necessarily to individual crop years. So far as it relates to fertilizer consumption it has decided regional and commodity, as well as national implications, and operates to the fullest extent in a freely competitive economy. Individual producers obviously do not all adjust in the same manner or to the same extent at a given time, but as a group the adjustments made have definite directional aspects.

Farm-management surveys generally show a positive relationship between crop yields per acre and net farm income. But the yields obtained may be influenced by several factors such as soil productivity, climate, crop rotations, variety and quality of seed, and the use of animal manures and commercial fertilizers. Under actual farming conditions it is most difficult to segregate and measure the effect on yields of these numerous factors. For the purpose of this discussion, however, this segregation and measurement is not necessary as we are interested primarily in developing criteria that indicate farmer reaction in the use of fertilizers and the effect of this reaction on future supplies of farm products.

PROFIT A FACTOR IN FARMERS' USE OF FERTILIZER

Without doubt agricultural production can be increased through the increased use of fertilizers. Results from numerous fertilizer experiments verify this statement. But farmers as a whole are interested more in the financial returns from farming than they are in the physical output, although at times the two are closely related. The question of costs and not returns, from the use of fertilizers, therefore, is of more concern to farmers than is the increase in physical production. Because of this, farmers in the United States, on the average, do not use quantities of fertilizer that will produce maximum yields per acre. Furthermore, because of risks in farming, primarily those of predicting prices for which the products will sell, and damage from weather, insects, and disease, few farmers follow the general practice of using the maximum quantity of fertilizer per acre that at a given time will return the maximum net return for its use.

In the case of cotton, for example, South Carolina farmers used an average of about 360 pounds of fertilizer per acre during the period, 1924-39, whereas fertilizer experiments at Bishopville, South Carolina, indicate that the average quantity of a 3 1/3-8-3 fertilizer that would yield a maximum net return for its use during the period was about 760 pounds. 5/ These averages do not describe the situation at any particular time in the 16-year period. The experimental data indicate that in 1924 when cotton prices averaged about 22.8 cents per pound, maximum net returns per acre would have been obtained with an application per acre of almost 1,600 pounds of fertilizer of the indicated analysis, and in 1931 when cotton averaged 9 cents, an application of about 220 pounds would have resulted in maximum net return from the use of the fertilizer (table 7).

It is doubtful if any appreciable number of South Carolina farmers used an equivalent of 1,600 pounds of 3 1/3-8-3 fertilizer per acre of cotton in 1924. In the first place, they had to contend with the possibility of serious boll weevil damage and they were not far removed from the collapse of cotton prices following the World War. Furthermore, there was no assurance at planting time that the crop would sell for nearly 23 cents a pound, and even if such a probability could have been recognized these farmers probably have learned through experience that beyond some point of application, successive additional units of fertilizer result in successively smaller additional yields.

In 1924, for example, the first unit of 200 pounds returned \$10.32 per acre above the cost of the fertilizer and the cost of picking and ginning the additional yield, the second unit of 200 pounds returned \$4.44 above these costs, and the third unit returned only \$2.51 above the additional costs (table 8). Stated in another way, the first 3 units (600 pounds) returned a net income of \$17.27 per acre greater than the net income when no fertilizer was used, and the next 4 additional units (800 pounds) returned an additional net income of only \$2.89 per acre.

In a year like 1931, when cotton prices were unusually low, the value of the additional yield of cotton and seed from the use of 200 pounds of fertilizer was only 13 cents greater than the cost of getting the additional yield. The yields from additional units of 200 pounds each were worth less than the additional cost for fertilizer plus costs of picking and ginning the cotton, until with an application of 1600 pounds of fertilizer per acre, the value of the production from the use of the fertilizer was \$11.56 less than the cost of obtaining the additional yield.

On an average, cotton farmers in South Carolina used during the 16 years only about 50 percent as much fertilizer per acre as would have given maximum net returns from the use of a 3 1/3-8-3 fertilizer. This is not so difficult to comprehend when it is understood that about 85 percent of the maximum net returns were obtained from use of the first half of the fertilizer.

5/ Obviously the most profitable quantity of fertilizer and the average quantity actually used are not exactly comparable because of differences in fertilizer analyses and variations in soil and growing conditions, but the wide differences shown have considerable significance.

Table 7. - Net returns per acre of cotton from the use of various quantities of fertilizer, South Carolina, 1924-39 1/

Year	Net returns from use of the following quantities of fertilizer -							
	200 : 400 : 600 : 800 : 1,000 : 1,200 : 1,400 : 1,600	lbs. : lbs.	Dollars : Dollars					
1924	10.32 : 14.76 : 17.27 : 18.74 : 19.58 : 19.97 : 20.16 : 20.15							
1925	8.17 : 11.27 : 12.70 : 13.22 : 13.19 : 12.78 : 12.18 : 11.40							
1926	3.43 : 4.03 : 3.63 : 2.71 : 1.43 : -.04 : -1.63 : -3.33							
1927	9.55 : 13.71 : 16.11 : 17.56 : 18.12 : 18.90 : 19.18 : 19.26							
1928	7.71 : 10.64 : 12.02 : 12.50 : 12.47 : 12.08 : 11.52 : 10.79							
1929	6.32 : 8.57 : 9.46 : 9.60 : 9.31 : 8.68 : 7.94 : 7.04							
1930	2.32 : 2.47 : 1.86 : .82 : -.47 : -1.92 : -3.48 : -5.14							
1931	.13 : - .86 : -2.27 : -3.93 : -5.74 : -7.03 : -9.57 : -11.56							
1932	1.29 : 1.03 : .23 : -.86 : -2.13 : -3.50 : -4.95 : -6.46							
1933	3.46 : 4.45 : 4.64 : 4.38 : 3.86 : 3.15 : 2.34 : 1.45							
1934	5.25 : 7.10 : 7.84 : 7.96 : 7.73 : 7.22 : 6.62 : 5.88							
1935	4.28 : 5.56 : 5.83 : 5.55 : 4.94 : 4.11 : 3.16 : 2.11							
1936	5.77 : 8.03 : 9.13 : 9.58 : 9.65 : 9.47 : 9.16 : 8.70							
1937	1.86 : 1.90 : 1.23 : .30 : -.90 : -2.25 : -3.66 : -5.14							
1938	2.53 : 2.96 : 2.66 : 1.99 : 1.00 : -.13 : -1.32 : -2.60							
1939	2.84 : 3.46 : 3.29 : 2.69 : 1.85 : .81 : -.30 : -1.49							
16-year average	4.70 : 6.21 : 6.60 : 6.43 : 5.39 : 5.11 : 4.21 : 3.19							

1/ Computations based upon the 7-year average results (1921-27) from cooperative fertilizer experiments at Bishopville, South Carolina, (Gross, E. E., A Compilation of Experimental Data on Cotton Fertilizers Applicable to The Hill Sections of Mississippi. Miss. Agr. Expt. Sta. Bul. 321, 94 pp. 1938. See p. 9.) and average prices of cotton and cost goods in South Carolina, by years, 1924-39. Net return per acre is the difference between the value of the additional cotton and seed obtained from the use of different quantities of a 3 1/3-8-3 fertilizer, and the cost of the fertilizer, and the picking and ginning of the increase in yield obtained from the use of the fertilizer. Adjusted 7-year average quantities of seed cotton obtained from the use of different quantities of fertilizer were used in making the above calculations. Actual and adjusted quantities are shown in figure 3 and table 9.

Table 8. - Additional net return per acre from the use of successive applications of fertilizer, 1924-39 1/

Year	Units of 200 pounds each of 3 1/3-8-3 fertilizer -								Cumulative total
	First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth	
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	
1924	10.32	4.44	2.51	1.47	0.84	0.39	0.19	-0.01	20.15
1925	8.17	3.10	1.43	.52	-.03	-.41	-.60	-.78	11.40
1926	3.43	.60	-.140	-.92	-.1.28	-.1.47	-.1.59	-.1.70	-.3.33
1927	9.55	4.16	2.40	1.45	.86	.48	.28	.08	19.26
1928	7.71	2.93	1.38	.48	-.03	-.39	-.56	-.73	10.79
1929	6.32	2.25	.89	.14	-.29	-.63	-.74	-.90	7.04
1930	2.32	.15	-.61	-.04	-.1.29	-.1.45	-.1.50	-.1.66	-.5.14
1931	.13	-.99	-.41	-.66	-.1.81	-.1.89	-.1.94	-.1.99	-.11.56
1932	1.29	-.26	-.80	-.09	-.1.27	-.1.37	-.1.45	-.1.51	-.6.46
1933	3.46	-.99	-.19	-.26	-.52	-.71	-.81	-.89	1.45
1934	5.25	1.85	.74	.12	-.23	-.51	-.60	-.74	5.88
1935	4.28	1.28	.27	-.28	-.61	-.83	-.95	-.1.05	2.11
1936	5.77	2.26	1.10	.45	.07	-.18	-.31	-.46	8.70
1937	1.86	.04	-.62	-.98	-.1.20	-.1.35	-.1.41	-.1.48	-.5.14
1938	2.53	.43	-.30	-.07	-.99	-.1.13	-.1.19	-.1.28	-.2.60
1939	2.84	.62	-.17	-.60	-.84	-.1.04	-.1.11	-.1.19	-.1.49
16-year average	4.70	1.42	.41	-.18	-.54	-.78	-.90	-.1.02	3.19

1/ See footnote table 7.

PRICES AND COSTS IMPORTANT

Increases in seed cotton per acre from additional applications of fertilizer were obtained in the Bishopville experiment. The first unit of fertilizer (200 pounds) produced 186 pounds per acre more seed cotton than was produced without fertilizer. Each additional application of 200 pounds of fertilizer increased the yield of seed cotton, but at a diminishing rate, until the eighth unit produced only 37 pounds in excess of the yield produced by the seventh unit. The total increase in yield from the use of 8 units, or 1,600 pounds of fertilizer, was 585 pounds of seed cotton (table 9 and fig. 3).

The yield data gives no indication as to the extent to which additional yields could be obtained from successive applications of 200 pounds of fertilizer. It is evident, however, that in most years during the 16-year period, 1924-39, the margin of economic return was reached long before the use of 1,600 pounds of fertilizer. Thus, in only 2 years was the maximum net return obtained from the use of about 1,600 pounds of fertilizer; in 5 years from the use of 800 to 1,000 pounds; in 5 years from the use of 500 to 700 pounds; and in 4 years from the use of from 200 to 400 pounds.

Table 9. - Additional yields of seed cotton from successive applications of fertilizer 1/

Successive units of fertilizer	Actual yield per acre of seed cotton from each unit	Adjusted yield per acre of seed cotton from each unit	Quantity of fertilizer used per acre	Adjusted yield per acre of seed cotton from use of indicated quantity of fertilizer
200 pounds per unit	Pounds	Pounds	Pounds	Pounds
1	186	186	200	186
2	97	97	400	283
3	74	74	600	357
4	57	57	800	414
5	40	50	1,000	464
6	92	44	1,200	508
7	52	40	1,400	548
8	37	37	1,600	585

1/ 3 1/3-8-3 fertilizer experiments at Bishopville, South Carolina.
(See footnote, table 7).

Variations in cotton prices accounted mainly for these variations in net return, although changes in prices of cost goods were important in some years. For example, in 1924 when cotton sold for nearly 23 cents a pound, each unit of 3 1/3-8-3 fertilizer returned a margin above costs until about 1,580 pounds were used. In 1932, on the other hand, the average price of cotton in South Carolina was only 7.2 cents a pound, and the maximum net return per acre was reached with an application of about 360 pounds of 3 1/3-8-3 fertilizer. For the 10-year period, cotton prices averaged 13.1 cents per pound and maximum net return per acre was obtained with the use of about 760 pounds of fertilizer (fig. 3).

YIELD OF SEED COTTON PER ACRE FROM APPLICATION OF INDICATED AMOUNTS OF FERTILIZER, AND NET RETURN PER ACRE FROM USE OF FERTILIZER IN SPECIFIED YEARS

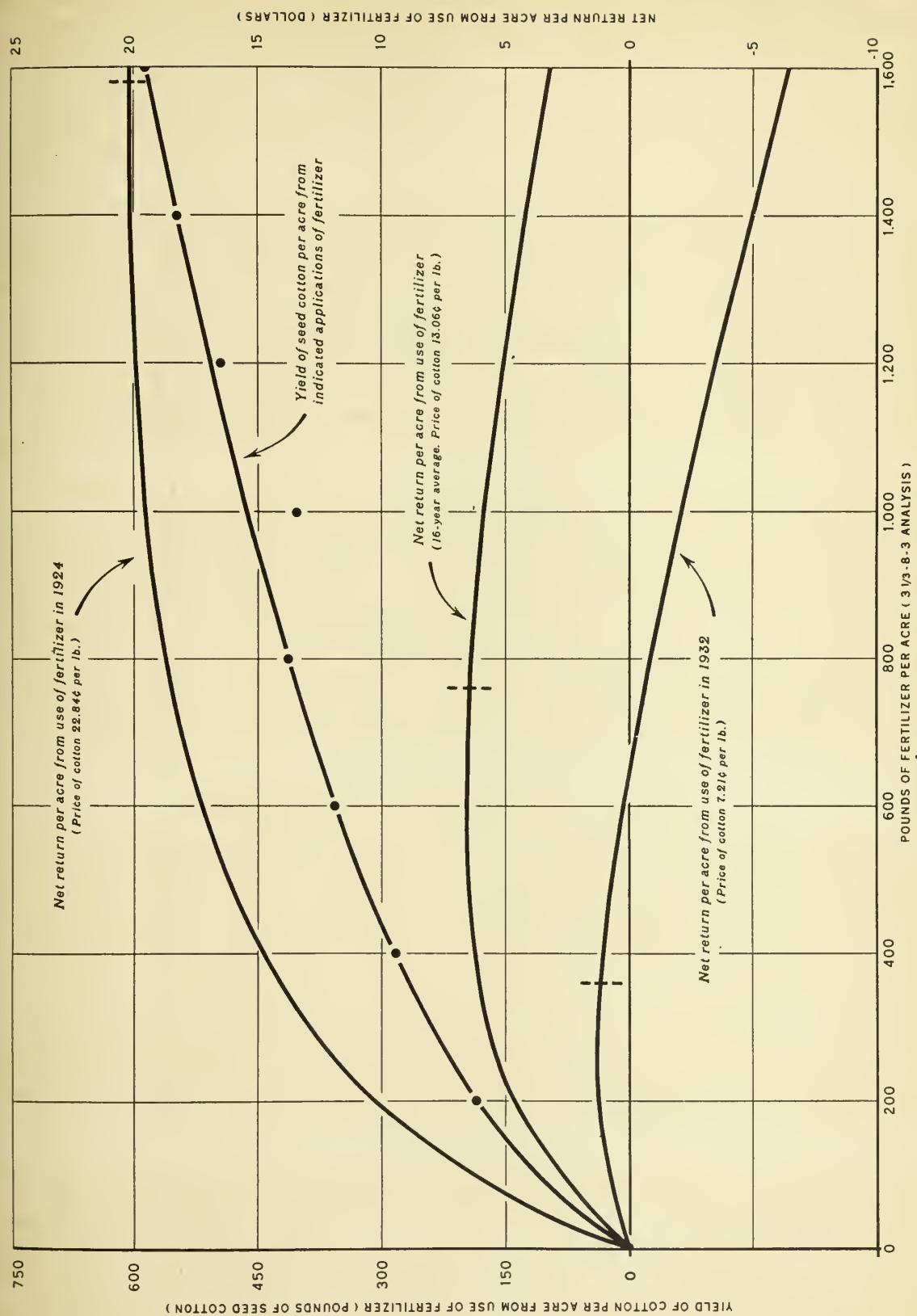


FIGURE 3

The slope of the net return curves in figure 3 and the illustrations in figure 4 help to explain the reason why the first units of fertilizer give so much larger net returns than do the latter units. These illustrations show that the costs of getting the additional yields decrease at a slower rate than the value of the additional yields. The reason is that fertilizer costs make up a very large part of the total production costs of the additional yield obtained from each unit of fertilizer (table 10).

The data cited are based upon experiments conducted at one place in South Carolina (Bishopville), and computations from experiments conducted elsewhere may not coincide exactly with those data. But the results presented do illustrate the difficulty of selecting in any year the quantity of fertilizer that will give the maximum net return per acre, and the reasons why farmers generally follow a rather conservative course in deciding upon the quantity per acre to use. Data show that although cotton farmers are generally conservative in their use of commercial fertilizers, the amount spent per acre for fertilizer follows the same trend as the amount that had given the maximum net return per acre in the preceding year.

The reason for this is that when the use of fertilizer on cotton is relatively profitable, the amount spent per acre for fertilizer is increased in the following year, and when its use is relatively unprofitable the amount spent is decreased the next year. South Carolina farmers as a group do not vary the amount spent per acre for cotton fertilizers as much as the variation in the index of the quantity that would give the maximum net return per acre. The reasons for this have been mentioned previously. These influences probably will continue to be important so long as cotton lands are plentiful and farmers as a whole have the choice of cultivating a large acreage and using moderate applications of fertilizer per acre.

QUALITY OF CROP IMPORTANT CONSIDERATION

Some crops in some sections of the country, such as tobacco, citrus, and vegetables require the generous use of fertilizers for efficient production and good-quality product, and producers of such crops probably have considerable difficulty in adjusting expenditures for fertilizer in line with gross income. Data obtained from fire-cured tobacco growers in southern Virginia show over a 17-year period a rather uniform yearly application of fertilizer, varying for the most part between 740 and 840 pounds per acre. During the same period the average yields varied from year to year, from about 420 pounds to 1,030 pounds per acre (fig. 5). Variation in the gross value per acre of tobacco was much greater than the variation in expenditure for fertilizer in the following year. 6/

6/ Based upon data obtained in farm-management surveys by the Bureau of Agricultural Economics in cooperation with the Virginia Agricultural Extension Service. The indexes of gross value per acre and price per pound of tobacco are charted for 1922-38, the average of which equals 100 percent. Expenditures per acre for fertilizers are charted for 1923-38, the average of which is equal to 100 percent. Fertilizing cost per acre in each year is charted with the gross value and price of tobacco in the preceding year.

ADDITIONAL GROSS INCOME FROM SUCCESSIVE UNITS OF FERTILIZER,
AND COSTS OF PRODUCING ADDITIONAL COTTON YIELDS,
16-YR. AVERAGE, 1924-39, AND 3 INDIVIDUAL YEARS

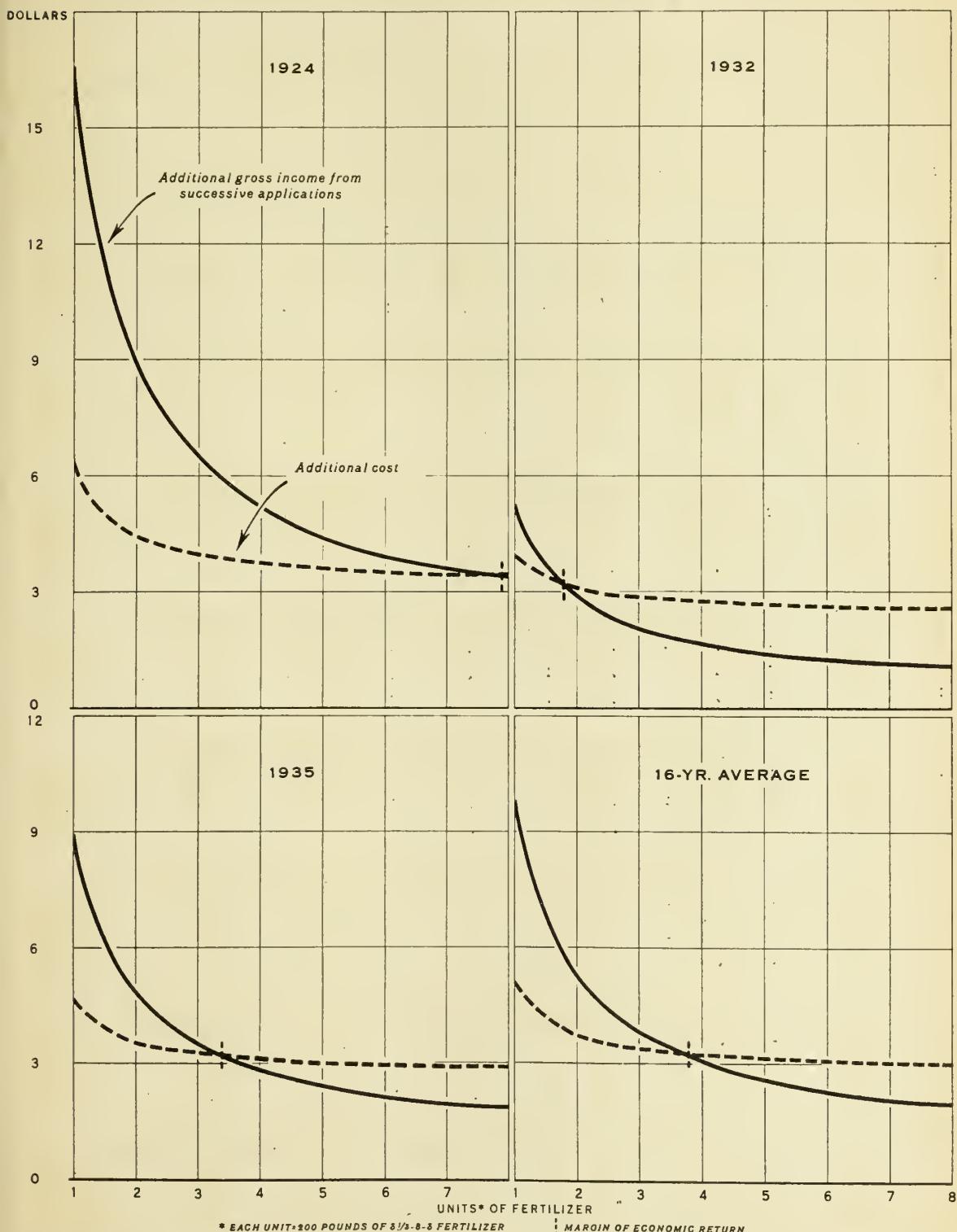
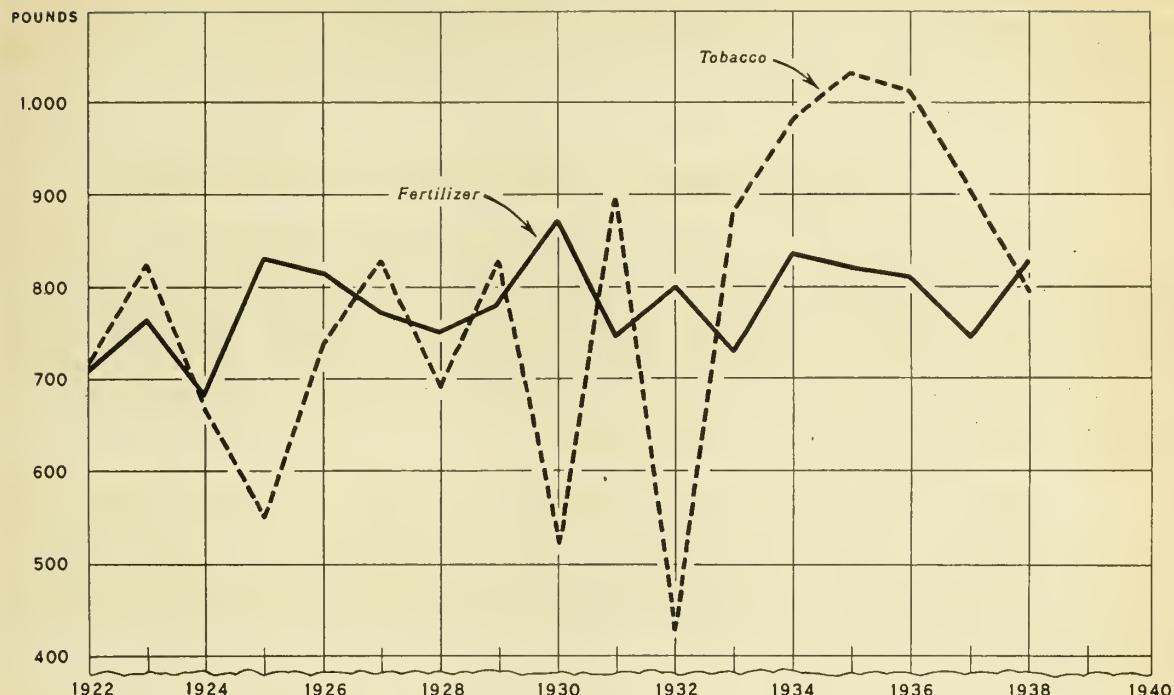


Table 10. - Costs incurred and value per acre of cotton lint and seed produced from each unit of fertilizer applied to cotton crops of South Carolina, in specified years 1/

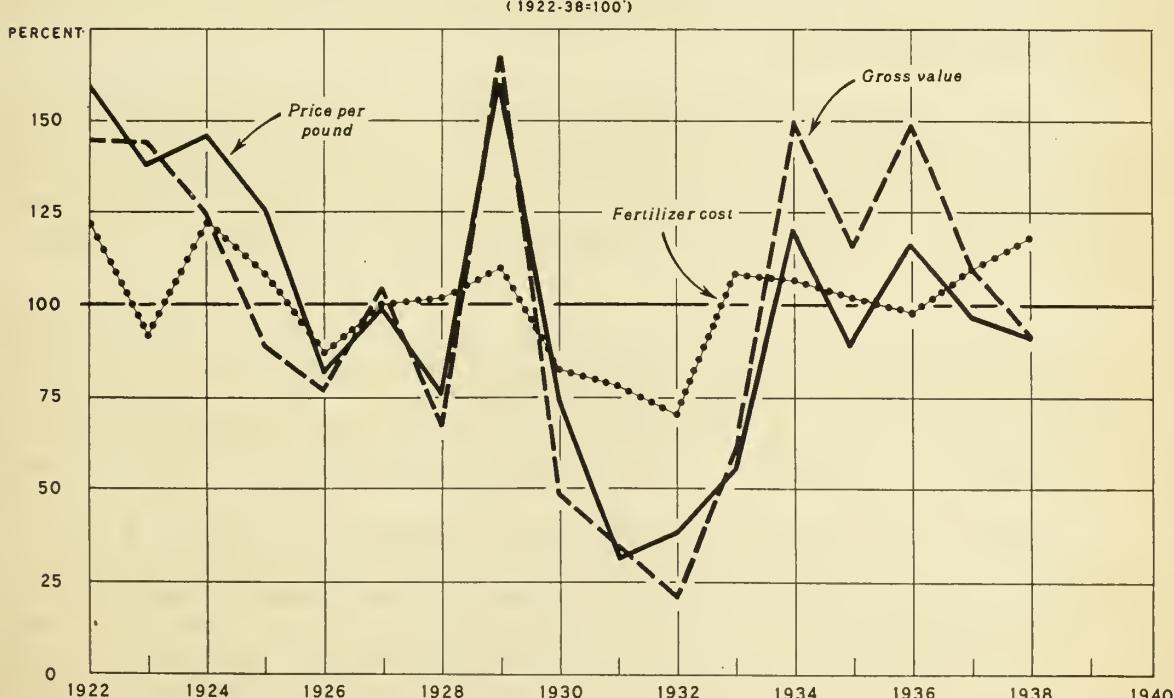
First unit of 200 pounds 3 1/3-3-3 fertilizer						
Crop	of	Cotton lint:	Cost per acre for -	Value of	Net return	from
produced	from	produced	Applying: Harvest, : Fertilizer	lint and market, and Total	seed produced	fertilizer use
of fertilizer	fertilizer	lizer	lizer	gin cotton:	produced	use
		Pounds	Dollars	Dollars	Dollars	Dollars
			Dollars	Dollars	Dollars	Dollars
1924		64	2.54	.70	3.05	6.29
1932		64	2.16	.32	1.47	3.95
1935		64	2.34	.46	1.85	4.65
Second unit of 200 pounds 3 1/3-3-3 fertilizer						
1924		34	2.54	.23	1.02	4.39
1932		34	2.16	.11	.73	3.05
1935		34	2.34	.15	.98	3.47
Third unit of 200 pounds 3 1/3-3-3 fertilizer						
1924		25	2.54	.24	1.20	3.98
1932		25	2.16	.10	.58	2.34
1935		25	2.34	.16	.72	3.22
Fourth unit of 200 pounds 3 1/3-3-3 fertilizer						
1924		20	2.54	.23	.95	3.72
1932		20	2.16	.11	.46	2.73
1935		20	2.34	.15	.58	3.07
Fifth unit of 200 pounds 3 1/3-3-3 fertilizer						
1924		17	2.54	.23	.81	3.53
1932		17	2.16	.11	.39	2.66
1935		17	2.34	.15	.50	2.99
Sixth unit of 200 pounds 3 1/3-3-3 fertilizer						
1924		15	2.54	.24	.72	3.50
1932		15	2.16	.10	.34	2.60
1935		15	2.34	.10	.42	2.92
Seventh unit of 200 pounds 3 1/3-3-3 fertilizer						
1924		14	2.54	.23	.67	3.44
1932		14	2.16	.11	.33	2.60
1935		14	2.34	.15	.41	2.90
Eighth unit of 200 pounds 3 1/3-3-3 fertilizer						
1924		13	2.54	.23	.62	3.39
1932		13	2.16	.11	.30	2.57
1935		13	2.34	.15	.38	2.87

1/ See footnote, table 7.

AVERAGE QUANTITY OF FERTILIZER AND YIELD
OF TOBACCO PER ACRE, 1922-38
11 VIRGINIA FIRE-CURED TOBACCO FARMS



GROSS VALUE PER ACRE OF TOBACCO, PRICE PER POUND, AND
EXPENDITURE FOR FERTILIZER IN SUBSEQUENT YEAR, 1922-38
AVERAGE FOR 11 VIRGINIA FIRE-CURED TOBACCO FARMS
(1922-38=100)



These data suggest that tobacco growers in the area recognize generally the futility of obtaining desirable yields and quality of tobacco without normal applications of fertilizer, and if it becomes necessary to curtail expenditures for fertilizers such curtailment is in the form of a reduced acreage rather than in the form of substantial reductions in fertilizer use per acre.

MODERATE INCREASE IN FERTILIZER USE SEEMS PROBABLE

The rapid increase in the use of commercial fertilizers for several years before the World War was a natural consequence of efforts to increase agricultural production because of the needs of a rapidly increasing population, and expanding market outlets in foreign countries. These outlets for our agricultural products, an important feature of favorable cost and price relationships at the time, provided a profit incentive for increasing production through the use of fertilizers.

During the war demand for increased supplies of farm products led to an expansion of the agricultural plant, and increased production costs. Farmers increased their expenditures for fertilizers in line with their gross income, but because of a shortage of some fertilizers and high fertilizer prices the tonnage used was less in most years of the war than it was immediately preceding the war.

From 1921 to 1930 trends in income from farm production, expenditures for fertilizer, and the tonnage of fertilizer consumed was upward. With the beginning of the World depression in 1929, these trends were reversed and continued downward until about 1932, when they were again reversed and continued upward until 1937.

Thus, since 1910 gross income from farm production has been closely related to expenditures for fertilizers. This relationship undoubtedly will continue to influence farmers in their use of fertilizer. Production and price risks will continue to dictate a conservative policy of fertilizer use in which acre applications are generally less than would return maximum yields.

Future trends in the consumption of plant food from commercial fertilizer, therefore, will depend to an appreciable extent on the world outlet for such crops as cotton, tobacco, wheat, and fruit, and the relation of prices of farm products to fertilizer prices. For the country as a whole, the consumption of plant food from fertilizers is likely to increase slowly.

In the South Atlantic States where more than 50 percent of the fertilizer is consumed, crops are at the present time heavily fertilized. Production of such crops as cotton, tobacco, citrus fruits, truck crops, and white potatoes has been ample, and in some years more than ample for the market outlets. Although consumption of plant food by these crops is not likely to increase materially from present levels, prospects favor the increased use of fertilizers on hay crops and on pastures in the area. Unless outlets for cash crops expand, it appears likely that increased

attention will be given to livestock, and this should be reflected in some increase in fertilizer use on hay crops and pastures, especially should Government payments be available for these purposes.

Fertilizer use in the South Central States, which consume about 15 percent of the total supply, is likely to increase only moderately. The increase will probably result more from soil depletion in some areas than from an increase in the acreage of cotton and other relatively heavy users of fertilizers.

Fertilizer consumption in the North Atlantic and the East North Central States, which normally consume about 25 percent of the total quantity of fertilizer used, is likely to increase very little in the next several years. Prospects for increased use are probably better for pastures and hay crops than for other outlets. Increased use on hay crops will depend on the extent to which alfalfa and other legumes displace timothy and mixed grasses. A marked increase in the acreages of legume crops for silage may occur.

Over a period of years, fertilizer use seems certain to increase in the West North Central States, and in the irrigated and more humid areas of the Western States. Its use is now very limited in most of these States. Use of fertilizer on such cash crops as sugar beets and potatoes will probably continue to expand slowly. Only moderate increases in fertilizer use are in prospect for other crops, and it may be several decades before plant-food consumption in such States as Iowa and Illinois approximates the plant-food consumption figure for Ohio in 1934 of about 10 pounds per acre of land for crop use.

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